With the author's compliments.

S. F. Kelly 2/11/29.

From the Transactions of the Royal Society of Canada
Third Series, Volume XXII, 1928

PRESIDENTIAL ADDRESS

The Plants of Canada Past and Present

BY

A. H. R. Buller, F.R.S.C.

Ottawa
Printed for the Royal Society of Canada
1928

APPENDIX A

PRESIDENTIAL ADDRESS

THE PLANTS OF CANADA PAST AND PRESENT

BY

A. H. R BULLER, F.R.S.C.

THE PLANTS OF CANADA, PAST AND PRESENT

I. Preliminary Remarks

During the past year events of great interest to us have taken place. We have celebrated as a happy and united people the sixtieth anniversary of Confederation; and, looking forward to the future with faith and hope, the Dominion Government has set aside $750,000 for the first unit of a Canadian National Research Institute which is eventually to cost $3,000,000 and which, doubtless, will be the source of much intellectual and economic progress in our country.

Also, since our last annual meeting several of the choice and master spirits of our age have passed into the shadow and the silence. Among them Field-Marshal Earl Haig who in France, in the long years of our trial, led the armies of the British Empire and led them to victory. He was great in the arts of war. And another passed who was great in the arts of peace—Thomas Hardy—the novelist. He died and was buried in Westminster Abbey, in the heart of London; and yet, as Ian Colvin has sung:

"He lives: the larks the clouds among,
The clouds among,
And deep in Dorset's darkling dales
The moon-enchanted nightingales
Thrill with his native song."

We have also to record with deep regret the loss of two of our Fellows, L'abbé Henri Simard and Mr. James White. Biographical notices of these Fellows are in the Report of the Council and are printed in the Proceedings of the Society.

II. Organic Evolution

Among the great generalizations of science not one seems more secure than that of organic evolution. The stratified rocks of the earth-crust form a great book some sixty miles thick, and scattered in its pages is many a fragmentary record of life in long past geological ages. Fossil evidence compels us to believe that plants and animals have been in existence on the surface of our planet for at least 100,000,000 years and probably much longer and that, during this great stretch of time, they have been undergoing slow changes, new

species coming into existence by descent from old species and old species ever and anon becoming extinct.

At the present day the world's flora consists of some 400,000 species of plants and the world's fauna of some 2,000,000 species of animals. All of the species of plants and animals which are living now are the descendants of plants and animals which existed long before the Cambrian rocks were laid down in a primitive ocean and long before the North American continent existed in anything like the form in which we know it today.

III. The First Traces of Plant Life

What are the first traces of plant life within the boundaries of this broad Dominion? For an answer to this question we must go with the palaeontologist to the oldest rocks of our country and with hammer and chisel extract from them their fossil remains. "In the never-idle work-shop of nature", as Mathew Arnold has called it, many strange plants have been woven on the loom of time and have left the traceries of their stems and leaves and the beautiful hexagonal patterns of their internal tissues in the sedimentary rocks; but the first products of the loom were doubtless too delicate and too frail for proper preservation.

A fossil of a plant gives us direct evidence of the former existence of plants. A fossil of an animal not only gives us direct evidence of the former existence of animals, but also indirect evidence of the former existence of plants; for the Animal Kingdom is dependent on the Vegetable Kingdom. If all plants were to be exterminated, all animals would soon die of starvation and the surface of our earth would become as barren of living things as is now the face of the moon. And so it has ever been: animals have always required, either directly or indirectly, plant food for their existence. Therefore, in our search for the first evidence of plant life in our native rocks, animal fossils are almost as interesting to us as plant fossils.

Among the charter members of the Royal Society when the Society was formed in 1882 and its first President was Sir William Dawson, who was also the first President of McGill University and a distinguished geologist. He was interested in the earliest forms of life. A curious structure found in the Grenville series of the Pre-Cambrian rocks of Canada and made up of thin alternating layers of calcite and serpentine appeared to him to have contained canals and passages, and in 1865 he pronounced it to be the remains of a

massive foraminiferous animal which he called *Eozoon canadense*, i.e. the dawn-animal of Canada. This interpretation is no longer accepted. It is now generally believed by mineralogists and palaeontologists that *Eozoon* is entirely inorganic and that it merely simulates in some degree the appearance of something which once had life. If, however, it had turned out that *Eozoon* veritably was an animal, then, since as an animal *Eozoon* must have depended for its existence on plant food, we should have good evidence of the existence of plants in that remote era of geological time which we know as the Pre-Cambrian.

Today there are certain low forms of aquatic plants known as Blue-green Algae which grow about the edges of lakes, pools, and springs, particularly hot springs, and which, owing to their absorption of carbon dioxide from the water, cause mineral matter, such as calcite and siliceous sinter, to be deposited on their exterior. The rock masses so formed are botryoidal or radiating in form and commonly laminated, and they are comparable with apparently similar deposits which have been found in almost all the geological systems from the recent to the most ancient. Such deposits are now being formed in the Green Lakes of New York State, in Australia, and elsewhere where streams come off limestone rocks or where the lake-water is rich in lime content. The calcium carbonate is not built into the substance of the Algae but merely envelops the algal colonies. Hence the cells are not preserved in these sediments. It is possible that *Eozoon* is one of the rocks that owe their origin to the activity of Blue-green Algae.

An American geologist, the late Charles D. Walcott, Secretary of the Smithsonian Institution at Washington, spent twenty years of his life studying the Cambrian and Pre-Cambrian rocks of western Canada and the United States. In the middle Cambrian rocks of Canada he opened up a fossil quarry in a band of shale—known as the Burgess Shale—3000 feet above Field, B.C., and 8000 feet above sea level. The materials of which the quarry rock is made were evidently deposited in sea-water which once teemed with marine invertebrate life; for from a body of the shale which was only 100 feet long, 15 feet deep, and 7 feet high Walcott extracted fossils of no less than 154 species of animals included under 94 genera. Among these animals, in a wonderful state of preservation notwithstanding that the shale bed had once been covered by more than 10,000 feet of younger rocks, were Jellyfish (Medusae), Annelid worms, Sea-cucumbers, Crustacea of numerous varieties including Trilobites,

and Brachiopods. All these animals doubtless depended directly or indirectly on plants for their food, and their occurrence is good evidence that marine plants were abundantly present in the seas which once covered the region which we now know as our Rocky Mountains.

Some of these marine plants, fortunately for us, have been preserved in the Burgess Shale, and Walcott found their fossilized forms in the same quarry that had yielded him such a profusion of fossil animals. The forms of the fossil plants indicate that the plants were Sea-weeds and, as examples, may be mentioned *Marpolia spissa* (a supposed Blue-green Alga), *Waputikia ramosa* (a supposed Red Alga), and *Dalyia racemata* (a supposed Red Alga). These algal remains occur as shiny black films on the surface of layers of hard siliceous shale. Like the fossil Trilobites and other animals with which they are associated, they have been flattened out into an extremely tenuous layer by the pressure of great sheets of superincumbent rock, but have retained their original outline and the arrangement of their parts. As the Burgess-shale algae are devoid of hold-fasts and show no sign of any point of attachment, it may be assumed that they were free-floating forms or that they had been torn from their substratum and had been floated into the quiet waters of a shallow bay, there to be covered by fine mud and thus preserved very much like dried flowering plants between sheets of herbarium paper.

IV. The Devonian Land Flora

The first land flora of which we have any knowledge was in existence in the Devonian or Old Red Sandstone Period. Sir William Dawson in 1859 described one of these early land plants from the Lower Devonian of Gaspé in eastern Canada, and he called it *Psilophyton,* which means the *naked plant,* in allusion to its naked leafless stem; and similar Devonian land plants have since been found in the State of Maine (U.S.A.), Scotland, Bohemia, Germany, Belgium, and elsewhere. Dawson's restoration is shown in the accompanying illustration[1] *Psilophyton* was a plant about two feet in height with a cylindrical woody stem about half an inch thick, and it grew erect from a tangled mat of creeping stems which were provided with rootlets for absorbing water. The stem was forked and more or less spinous and its young branches were circinate at their tips. The epidermis, like that of the green stems and leaves

[1]Shown on a screen. The Address was illustrated with 95 lantern slides, several models, etc.

of Flowering Plants of today, was provided with stomata—little apertures—through which, doubtless, the carbon dioxide of the atmosphere passed into the plant there to be used in photosynthesis, that wonderful physiological process in which, with sunlight as the source of energy, carbon dioxide is combined with the elements of water to form sugar.

The internal cellular structure of the upright stems has been well preserved and, when sections of a stem are studied under the microscope, the long pointed fibres known as tracheides, of which the wood is composed, can be clearly seen. The fruiting organs consisted of naked oval spore-cases, usually borne in pairs on slender curved pedicels which were either lateral or terminal on the smaller branches.

The restoration of *Psilophyton* was based on fragmentary material and, for a long time, botanists regarded it with but little favour. One high authority even went so far as to doubt whether it was worth while to keep up the genus *Psilophyton* at all, so little did he think of it. However, time has been on Dawson's side. A fossiliferous Lower Devonian bed of great palaeobotanical interest was discovered by the geologist Dr. Mackie in 1913 at Rhynie in Aberdeenshire, Scotland, and the well preserved plants which it contains have been thoroughly worked out by Kidston and Lang in a series of memoirs published in 1917-1921. Among the Rhynie plants are the following: *Rhynia Gwynne-Vaughani, R. major, Asteroxylon Mackeri,* and *Hornea Lignieri.* Kidston and Lang's description of these species, which are members of the first known land flora, prove that they are closely related to Dawson's *Psilophyton* and confirm his account of that plant. The upshot of all this is that *Psilophyton* has become the type of a newly-recognized Class of vascular plants—the *Psilophytales* of Kidston and Lang; and, as the eminent palaeobotanist D. K. Scott has said, *Psilophyton* now "must rank as one of the most important of fossil plants". Thus "the stone which the builders rejected, the same is become the head of the corner".

V. The Great Ice Age and Plant Migration

With the help of long strides through geological time we now come to the Great Ice Age. As you are all aware, with the advent of the Pleistocene Period the Dominion of Canada grew colder and colder until at length it became almost covered by vast sheets of accumulated snow and ice. In his excellent book called *Ice Ages, Recent and Ancient,* published in 1926, one of our Fellows, Professor

A. P. Coleman of the University of Toronto, has discussed the various ice ages which our earth has known from Pre-Cambrian times to the present day, and according to him at least one glacial period, namely, the Permo-Carboniferous, exceeded the Great Ice Age in intensity. Ice ages must have an important influence on organic evolution by forcing plants and animals to migrate for hundreds or thousands of miles from one country to another, by exterminating many species, and by eventually making room for the spread of other species.

According to Coleman, in North America during the Great Ice Age three great continental ice-sheets were formed: the Cordilleran, the Keewatin, and the Labradorean.

The Cordilleran, or western mountain ice-sheet, accumulated over the whole of British Columbia and, in its central parts, reached an elevation of 8000 feet. "The ice at some points" says Coleman "was a mile thick" and "the loftier mountains must have appeared like islands rising out of a sea of white".

The second great ice-sheet, appropriately christened by J. B. Tyrrell the Keewatin ice-sheet, was the next to appear. It arose from a vast nevé which accumulated on comparatively low ground to the west of the Hudson Bay. It pushed out in all directions: it extended 2000 miles from north to south and 1300 miles from east to west, and its area where most widely extended must have exceeded 1,500,000 square miles. The Keewatin ice-sheet was a mighty geological agent. One of the most extraordinary things that it did was to transport Archaean boulders from the Laurentian area near Hudson Bay to the foot-hills of Southern Alberta where, as shown by G. M. Dawson, they were deposited at a level of 4,500 feet. The Keewatin ice-sheet must have driven every plant and every animal out of the Prairie Provinces; and, doubtless, if we could have been set upon the top of the ice-sheet above what to-day is Winnipeg, we should have observed, as far as the eye could reach, naught but a great and but gently sloping plain of ice. In the Sahara and other sand deserts there are oases in which plants and animals are to be found, but on such an ice-desert as once covered Manitoba, Saskatchewan, and Alberta, no living thing could possibly exist.

The third great continental ice-sheet was the Labradorean. It probably began to be formed later than the Keewatin ice-sheet, but eventually coalesced with it. It covered the whole of eastern Canada and extended south in the United States to New York and Cincinnati. The Labradorean and Keewatin ice-sheets combined to cover an area of at least 3,500,000 square miles and, for a considerable time, the

Hudson Bay was filled with ice. The thickness of the central part of the Labradorean ice-sheet is unknown, but in northwestern Labrador the ice-sheet was about 2000 feet thick, in southern Quebec about 2500 feet thick, and in Newfoundland about 1000 feet thick.

The Labradorean ice-sheet, like the Keewatin ice-sheet, caused an emigration of the plants from Canada into the United States on a grand scale, but certain plants held their ground on mountains in Labrador, the Gaspé Peninsula, and Newfoundland. The tops of these mountains projected up above the ice as islands: they resembled the nunataks that can be seen in Greenland at the present day.

When the climate of Canada grew warmer again, the ice gradually melted and, as the surface of the land became exposed to the light of day, plants and animals which had been kept out of Canada for tens of thousands of years returned to their old homes. Immigration took place on a vast front in the rear of the retreating ice-sheets, with the result that the plants of Canada came to have the stations in which we find them today.

There is still one great ice-sheet left in North America, namely, that of Greenland. In a recent exploration of Greenland, made by Koch, Harris, and Rosenkrantz, large quantities of coal in easily workable seams were found there and also fossil palm trees indicating that Greenland once had a tropical or subtropical climate. It may be that the Great Ice Age is not yet completely over, that the climate of North America is destined to become much warmer than it now is. Possibly the ice-sheet of Greenland will gradually melt away, Greenland's icy mountains lose their cold mantles, and the great island indeed become a green and pleasant land in which to live; and it may be that, in the time to come, the corn-belt of North America will move upwards into the Prairie Provinces and Stephanson's "friendly Arctic" become even more friendly than it now is. We can, of course, do little more than guess what changes this earth will see in the next million years; but, judging by the ups and downs in past geological history, it seems most probable that our climate at some future geological period will be much warmer than it is at present. Canada was once an ice-desert; she is now, according to Kipling, "our lady of the snows"; some day she may be a land of genial warmth the whole year round. If that day should ever come, it will bring with it great changes in the flora and fauna of Canada.

VI. The Relic Flora in Eastern Canada

It was stated that certain mountains in Labrador, Gaspé, and Newfoundland projected above the Labradorean ice-sheet and that these nunataks were places of refuge for the plants which previously had inhabited the valleys and lowlands. The geological evidence of the existence of unglaciated mountain tops has been provided by Coleman and others. When a continental glacier sweeps over disintegrated rocks, it disturbs them and is apt to carry away all the loose pieces and to smooth over the bed-rock. On the other hand, where the ice-sheet has not passed, disintegrated rock surfaces are left intact. An American botanist, Dr. Fernald of the Gray Herbarium, has recently published an important memoir called "Persistence of Plants in Unglaciated Areas of Boreal America". He has shown that, wherever there were nunataks projecting above the Labradorean ice-sheet, there one today finds a special flora—a relic flora—the plants of which are relics of a Pre-Pleistocene flora and once had a much wider area of distribution than they have now.

Among the scores of plants which survived on mountains which were not submerged beneath the ice-sheet a few examples may be mentioned.

Polystichum mohrioides var. *scopulinum* is a peculiar rigid fern. It is only known in twelve stations, eleven in western Canada and the United States, and one station in the Shickshock Mountains in Gaspé. This eastern station is 2000 miles from the nearest of the eleven stations in the west. It is believed that in Tertiary times the fern under discussion had a wide distribution in North America, but that the ice exterminated the species except where it took refuge on unglaciated mountain tops in Gaspé.

Woodsia scopulina, another fern, is a cordilleran species. About 1200 miles east it reappears in the Nipissing District of Ontario and about 700 miles farther northeast it abounds as an isolated colony on dry cliffs of the Shickshock Range in Gaspé. Here, again, we must explain this isolated colony as due to survival from Tertiary times on unglaciated mountain tops.

Agoseris is a genus of dandelion-like Compositae which occurs in western North America. One of the most characteristic species is *A. gracilens* which is found along the mountains of Alberta and British Columbia and in northern California, Nevada, Utah, and Wyoming. On Mt. Albert in Gaspé occurs *A. gaspensis,* the only known *Agoceris* in the eastern mountains: it differs in its fruit from *A. gracilens* and

is clearly a distinct endemic species, one peculiar to the Shickshock Mountains; and its nearest relative is 2000 miles to the west.

Another plant of the relic flora is *Circium minganense,* a Thistle discovered by Frère Marie-Victorin of the University of Montreal and described by him in our *Transactions* in 1925. It grows to a height of three feet or more and is a very showy plant with pale purple flowers; and it cannot be confused with anything else even by a beginner. It is a sea-shore plant, a halophyte exhibiting succulence, and it occurs on some islands of the Archipelago of Mingan in the Gulf of St. Lawrence. Its nearest living relative is a closely related white-flowered species, *C. foliosum,* which occurs in subalpine valleys in the Rocky Mountain region 2000 miles to the west. *C. minganense,* although very restricted in its range, has thousands of blown seeds and yet, like other relic species, does not spread into new territory.

It is believed by Fernald that the old Tertiary plants which survived the ice-age on unglaciated mountains in Labrador, Newfoundland, and the Gaspé Peninsula lost their pioneering potentialities during their long isolation and that, during the whole of Post-Pleistocene time (some 25,000 years), they have remained at or very near their old stations, leaving to other plants, namely, immigrants from the south and the east, the task of multiplying and spreading over those vast stretches of land that became available for occupation by plants when the great ice-sheets melted and disappeared.

VII. The Number of Species of Plants in Canada

The number of species of Flowering Plants and Ferns in the flora of Canada is about 5000; but if to these were to be added all the non-vascular Cryptogams—the Bacteria, Slime-moulds, Fungi, Fresh-water Algae, Marine Algae (Sea-weeds), Lichens, Liverworts, and Mosses—the total would be more than doubled. There are, therefore, upwards of 10,000 species of plants great and small which, as our fellow organisms each endowed with its own individuality in structure and function, are living in this country and sharing it with us. Their ancestors came to Canada, or were evolved in it, long before either the white man or even the red Indian knew that North America was in existence, and we may think of them, along with the animals that followed in their wake, as the original pioneers and the first occupants of the land which in our pushfulness and pride we are pleased to call our own.

VIII. Undesirable Immigrants

In addition to the native plants there are now in this country many hundreds of plants which have been introduced by accident or design by man. Among the undesirable immigrants that settlers have brought with them are our worst weeds, such as the Sowthistle, the Russian thistle, the Russian Pigweed, the so-called Canada Thistle, the Cockleburr, *et hoc genus omne* (good Canadians, truly, since they have been here for more than three generations), which flourish like the proverbial green bay tree, causing great trouble and expense to the cultivators of the soil. Sixty per cent. of Canadian weeds have been introduced from other countries. Like the biblical poor, the weeds are always with us: they can be kept in check only by constant vigilance, but not exterminated entirely. Unfortunately, they produce many seeds easily spread by the wind or other agencies, and the seeds are apt to lie dormant in the soil for years ready to germinate as soon as the plough brings them to the surface of the ground. The number of weed seeds which may lie hidden from view in arable land is almost incredible. Miss Brenchley, making her investigations in a wheat field at the famous Rothamsted Experimental Farm in England, found that there were 300,000,000 living Poppy seeds per acre. It is the astounding number of weed seeds which find their way into the soil and their tenacity of life which make weed eradication so difficult.

IX. Forests and Forestry

Among the glories of Canada and one of her greatest material assets are her extensive forests in which there are about 160 species of plants attaining the size of trees. Of these species 31 are conifers, principally Spruces and Pines, and their wood makes up 80 per cent. of our standing timber.

It is true that there are great treeless plains in the north—around the Hudson Bay, in the Northwest Territories, and in the Yukon—and that there are many mountains above the timber line in British Columbia; and it is also true that in Manitoba, Saskatchewan, and Alberta there is a great prairie area almost devoid of trees and distinguished by the dominance of grass plants. Nevertheless, on the whole, Canada is rich in forests. It has been estimated that of the total area of Canada (approx. 3,650,000 square miles) about 1,227,000 square miles are forest-covered: in other words, one square mile out of every three is occupied by trees. Every traveller who comes to the Dominion by the St. Lawrence route and proceeds by train to

Winnipeg must be impressed with the never-ending procession of Spruce trees, Pines, Poplars, and Birches as he passes through our great eastern coniferous forest for upwards of 1500 miles. Below the eastern coniferous forest, stretching from Lake Huron to Nova Scotia and the Atlantic coast, are hardwood and mixed forests characterized by the presence of such hardwood trees as Maple, Birch, Beech, Elm, Ironwood, Willow, and Poplar. Extending west for nearly 2000 miles from western Ontario through the northern halves of the three prairie provinces to the mouth of the Mackenzie River, the eastern belt of forests is continued as mixed forest in which Spruce, Birch, Tamarack, Poplar, and Willow predominate. Between the prairie region and this northern forest there is a transitional zone in which are clumps or groves of Poplar interspersed with open prairie patches covered with long coarse grass. In the west is the great coniferous forest of the mountain ranges and the Pacific coast. Around Banff and in numerous localities in British Columbia where fire has been, the Spruce has given place to the Lodgepole Pine. In the Island of Vancouver, the Douglas Fir attains immense proportions, sometimes growing to a height of 300 feet with a circumference of 30 to 50 feet and the great trunk bare for the first 150 feet, so that, as one looks up from the ground, the individual leaves on even the lowest boughs cannot be distinguished. When once seen, these giant conifers make upon the mind an indelible impression of strength and grandeur in the Vegetable Kingdom.

The Province of Ontario, especially in the peninsula which lies between the Great Lakes, possesses a greater variety of trees than any other part of the Dominion. Here are found trees which grow nowhere else in Canada: the Tulip tree, the Black Gum, the Chestnut, the Papaw, the Flowering Dogwood, and others characteristic of the forests of Ohio and of other States to the south. Similarly, in the west of British Columbia, where the climate is mild and humid, occur many species of trees, e.g. the Arbutus and the Garry Oak, typical of more southern forests and found nowhere else in Canada.

Manitoba, owing to the severity of its climate, is relatively poor in tree species. The absence from Manitoba of one eastern species, namely, *Acer saccharum,* which provides us with our national emblem, may be especially noticed. In the Maritime Provinces, Quebec, and eastern Ontario this splendid tree not only is a valuable source of hardwood but, in the spring, yields excellent maple sugar and, in the autumn, with its firey tints sets the woods aglow. In Manitoba, the place of the Sugar Maple is taken by the Manitoban Maple, *Acer*

Negundo, which is a hardier tree but which, unfortunately, is not a good sugar-producer and has leaves which, when dying, take on but a yellow hue. The Manitoban Maple does not grow naturally in eastern Canada, but it flourishes in our Manitoban woods, along streams and the margins of lakes, and it is used to ornament the boulevards of Winnipeg and many other western cities.

Trees *will* grow on the treeless prairie land of western Canada; and, to supply the requirements of the prairie farmers who need trees for wind-breaks, for wood-lots, and as ornaments about their homes, the Dominion Government, principally from its great forest nurseries at Indian Head and Sutherland (near Saskatoon) sends out yearly about 6,000,000 saplings.

In Manitoba, it is a matter of common observation that the Poplars are advancing on the prairie, and many new groves of young Poplars can now be seen in places where 25-30 years ago there was only grass-land. This invasion of the prairie by trees has perhaps been made possible by the settlement of the country and the consequent cessation of prairie fires.

Economically the forests of Canada are of vast commercial importance. Our own national income depends on our forest industries more than on any other source except agriculture. In Europe as a whole including Russia, according to Fraser Story, the annual consumption of wood is 9,000,000,000 cubic feet and the growth or annual income only 6,000,000,000 cubic feet, so that Europe is eating into her forest capital at the rate of 3,000,000,000 cubic feet a year. The same tale of diminishing forest capital is true for North America, and it has been estimated that the yearly drain on Canadian forests through fires and other destructive agents and through industrial consumption is 4,000,000,000 cubic feet. Story estimates that "of a total volume of a million million cubic feet of timber in the world, 27½ thousand million are consumed annually so that, setting aside the question of re-growth which must be slow and uncertain, the virgin coniferous forests of the world cannot last at the present rate for more than 37 years". This is an alarmingly short period for the exploitation of a commodity which is in universal demand and which, after food and clothing, is next in importance among the prime necessities of life. As in the future the shortage of soft-wood timber makes itself felt, prices must rise. It therefore behoves us as Canadians, both in our own interests and in the interests of civilization the whole world over, to take the best care we can of our forests, not only by exploiting them economically, not only by preventing fires,

not only by checking the ravages of insect and fungus parasites, but by looking to the future and providing for reaforestation wherever that is practicable. In view of the approaching famine in soft-woods, like France and Germany, we must develop a strong forest consciousness.

Canada not only supplies to the world vast stores of timber, but she is now firmly entrenched as the leading newsprint manufacturer of the world. Canadian mills now produce more than one-third of the world's newsprint. In 1926 she produced 2,420,000 tons of newsprint, thus leading her nearest competitor, the United States, by almost one million tons (U.S. output 1,500,000 tons). The permanency of the pulpwood industry depends, of course, on the supply of wood available in our Canadian forests and, unless methods of conservation and reaforestation are vigorously employed, there must be a termination to the industry within a few decades.

There are commercial possibilities other than timber and pulpwood for the wood grown in Canadian forests. A witty Englishman once said: "a generation ago, to make a woman's clothes, it took two sheep, but today it takes just one solitary silkworm". This statement would be nearer the truth with a slight amendment. Instead of "just one solitary silkworm" it should read "just one solitary silkworm or a few branches of a Spruce tree"; for, as you are all aware, most of the silk garments of today are made of artificial silk or rayon, and rayon is spun from cellulose obtained from Spruce wood. Count Hilaire de Chardonnet produced artificial silk in 1889. In 1909 the world's production of artificial silk was 7,500 tons, but in 1926 it had risen to 100,000 tons. The possibilities for rayon manufacture in Canada with her vast pulpwood areas are enormous, and already one artificial silk plant has been established in Ontario. Doubtless this is but the harbinger of many others.

Another possible use for our wood, and even for sawdust, is the making of sugar. Trees manufacture the cellulose of which their cell-walls are composed from sugar which in the first place is synthesized in the green leaves, and they have been doing this most successfully for many millions of years. For an equally long period the wood-destroying fungi have been reversing the process: they have been attacking the wood with enzymes or organic catalysts and have been converting the cellulose into sugar. Millions of tons of cellulose every year are converted into sugar by fungi and used by them as food in the upbuilding of their fruit-bodies—the Polyporei and the Mushrooms and Toadstools of our forests. Man's modern industrial problem is to emulate the wood-destroying fungi and convert cellulose

into sugar in a rapid and efficient manner. A laboratory method of converting cellulose into sugar has been devised in Germany and is now being tested on a commercial scale. The cellulose of sawdust, etc., is "saturated by hydrochloric acid gas in the presence of catalysts. In a period of under one hour the whole of the cellulose content is converted into glucose. This glucose is then treated for removal of the acid, and can either be sold as cattle food or refined as pure white glucose for human consumption, or it can be fermented into alcohol for fuel for industrial or potable purposes. As much as 60 per cent. of the weight of the dried sawdust has been obtained in pure sugar". There is therefore the possibility that, in the future, sugar may be added to silk as an important product of Canadian forests.

X. The White Pine Blister Rust Disease

Our forest trees, unfortunately, suffer not only from the ravages of fire and wasteful human practices but also from parasitic enemies. The Spruce Budworm, the Larch Sawfly, and the Bark-boring Beetles may be mentioned as examples of insects which yearly do great damage to our forests. They are being fought with energy and effectiveness by our Dominion entomologists. As an example of a disease of forest trees due to fungi, we shall now consider the White Pine Blister Rust caused by a parasitic Rust fungus.

The White Pine is the tallest and most stately conifer in eastern Canada and the northeastern part of the United States and, where it occurs, it is the most valuable tree of the forest. It grows rapidly, has excellent wood, its yield of wood per acre is high, and it is very adaptable to forest management. In the United States, White Pine is grown in rotations of 40-60 years and, in many sections, it yields a profit of $5 to $10 per acre per year. Not only are White Pines wonderful producers of merchantable timber, but they are a delight to the eye and, owing to their high ornamental value, are often planted as lawn trees in parks and private grounds.

The White-pine blister rust is a forest-tree disease, possibly of Asiatic origin. It was first noticed in Europe on White Pines introduced from the United States. Owing to the outbreak of the disease in Europe, the growing of White Pines in that continent for forestry purposes has largely been given up.

The blister-rust disease was accidentally introduced into the United States and Canada from Germany on diseased White Pine stock upwards of twenty-five years ago, and it has now become established

in the United States and Canada in both the eastern and western regions. In Canada it occurs in the Provinces of Ontario, Quebec, Prince Edward Island, New Brunswick, Nova Scotia, and British Columbia, while in the United States it occurs in the New England States, New York, Pennsylvania, Michigan, Wisconsin, Minnesota, and Washington.

The blister-rust disease is caused by a parasitic fungus known as *Cronartium ribicola* which kills the bark of White Pines and thus causes their death. The fungus is peculiar in its demands on its host-plant, for it limits its attack to five-needle pines, such as *Pinus strobus* (White Pine) and *P. monticola* (the Western White Pine) and leaves untouched all two-needle pines, such as *Pinus Banksiana* (the Jack-pine) and *P. resinosa* (the Red Pine).

The blister-rust fungus infects the bark of White Pines through the needles. A spore settles on a needle and germinates there. The germ-tube makes its way through a stoma into the interior of the leaf and, as a result, a yellow leaf-spot is developed. Once inside the leaf, the parasite—by means of its thready mycelium—grows down the needle into the stem. It then vegetates in the bark, spreading out from the point of attack and forming a canker. The canker usually completes its ripening in the third year after infection has taken place and then, from April to June, orange-yellow blisters about the size of a small bean burst through the diseased bark. These blisters are sac-like outgrowths and contain millions of microscopic reproductive bodies known as spores (aeciospores). These spores may be called *spring spores* to differentiate them from other spores which, as we shall see, the fungus produces in the summer and autumn. When ripe, the sacs break open and then the spring spores, like dust, are carried off by the wind and scattered far and wide.

The bark ruptured by the fungus dies. The mycelium or vegetative part of the fungus continues to grow in the healthy bark bordering the canker and, each successive spring, produces new blisters or spore-sacs. Thus each canker is a source of new spores each year until the limb or trunk on which it is situated has been killed. Young trees may be girdled and killed in a few years. Older trees may survive for a longer time. On older trees the first signs of damage appear as scattered dead and dying branches sometimes called "flags". From these diseased branches the fungus grows back into the trunk. After the tree has been girdled, the portion of the tree above the canker dies and in course of time may break off. The fungus continues to grow down the tree through the healthy bark with the inevitable result that, in

the end, the whole tree is killed. Where a canker occurs on a trunk, the growth of annual rings of wood is greatly retarded. White Pines weakened by blister-rust become attacked by other fungi and by insects, and the dead trees are soon destroyed by these agencies.

The White-pine blister-rust fungus, like many other rust fungi, such as those of Wheat and Apples, is *heteroecious,* i.e. in the course of its life-cycle it lives on two different host-plants. One of these host-plants, as we have seen, is a five-needled pine, such as the White Pine. The other host is a species of *Ribes, Ribes* being the generic name for all species of Currants and Gooseberries.

Early in the spring, the spring spores (aeciospores), which escape from the White-pine blisters, are blown by the wind on to the leaves of wild and cultivated Currants and Gooseberries, and there they germinate and grow into the leaf tissue. The spring spores cannot grow on any other plants than species of *Ribes* and they cannot infect the White Pine. Thus the fungus cannot spread from pine to pine but only from pine to *Ribes* species and, as we shall see, back again from *Ribes* species to pines.

After the blister-rust fungus has infected the leaf of a currant or gooseberry bush, it vegetates in the internal tissues of the leaf for some three weeks. At the end of this time, small orange-yellow pustules appear on the under surface of the leaves. These pustules (uredo-sori) break open and liberate a great number of *summer spores* (uredospores) which spread the disease on currants and gooseberries from leaf to leaf and from bush to bush, rapidly producing new infections. This is repeated several times during the growing season so that the currant and gooseberry bushes become more and more infected.

From late June until the foliage dies, brownish hairlike outgrowths of the fungus appear on the under side of the diseased currant and gooseberry leaves, and these new outgrowths (teleutospore-sori and teleutospores) liberate certain delicate *autumn spores* (sporidia) which cannot re-infect currant and gooseberry leaves but which can and do infect the leaves of the White Pine and other five-needled pines.

We thus see that the blister-rust fungus, by means of its spores, passes from the White Pine to Currants and Gooseberries, and from Currant and Gooseberries to White Pines. The spring spores (aeciospores) produced in the blisters on the White Pines are long-lived and spread the rust for miles from infected pines to healthy currant and gooseberry bushes. On the other hand, the autumn spores are short-lived and consequently spread the rust from currants and goose-

berry bushes to White Pines for comparatively short distances, i.e. for a few hundred feet only.

The short infecting range of the autumn spores makes it possible to control the rust locally by the eradication of all the wild currant and gooseberry bushes growing within 900 feet of the Pine trees. The cost of the currant and gooseberry eradication work on 3,450,000 areas in the United States has averaged 25 cents an acre, and these control measures have been found to be reasonable and profitable. In Canada and the United States it is impossible to eliminate the blister-rust disease entirely; but, through our knowledge of the life-history of the causal fungus, it is now possible to protect any stand of White Pine: all that is necessary is to eradicate all the wild currant and gooseberry bushes within 900 feet of the nearest pine trees. Thus does the phytopathologist come to the help of the forester and timber merchant.

Into British Columbia the blister-rust fungus was unfortunately introduced a few years ago and now it has spread far and wide. It has passed from Canada to the United States and is attacking all the five-needled pines which it meets in its progress, e.g. *Pinus monticola* (the Western White Pine) and *P. lambertiana* (the Sugar Pine) Already it has become a serious disease in a very valuable and extensive western forest area.

XI. The Introduction of Plant Diseases

Several of the worst plant diseases in North America have been introduced from other countries. Thus the blister-rust, which has spread so alarmingly on White Pines, came from Europe; the Chestnut tree blight, the most virulent and devastating disease of a forest tree that has ever been recorded and which threatens to exterminate the American Chestnut tree from its native haunts, was introduced from China; while the Citrous canker, a serious bacterial disease of Oranges and Grape-fruits, was introduced from Japan. It is facts of this kind which have made it necessary for Canada and the United States to organize services for the rigid inspection and control of plants introduced from abroad.

XII. A Botanical Survey

The plants of Canada have been collected and studied to some extent for more than two centuries. Canada can even boast of a pre-Linnaean flora in MS. form written about the year 1698. This

work was recently found by Frère Marie-Victorin, through the courtesy of Monseigneur Choquette, in the Roman Catholic College at St. Hyacinthe, Quebec. It is entitled *Histoire des Plantes de Canada.* The author is unknown, but probably he was a correspondent of the celebrated French botanist Tournefort. The MS. enumerates about 250 species of plants which are well described and, in some instances, discussed at length. This unique document is probably the oldest botanical paper ever written in North America, and it will be published by Frère Marie-Victorin in due course as one of the *Contributions du Laboratoire de Botanique de l'Université de Montréal.*

Michel S. Sarrazin, physician and naturalist, lived at Quebec. He was born in France in 1659 and arrived in Quebec in 1685, and several years later he was elected a member of the French Academy. He was also appointed King's Physician and had the honour of being the only bearer of that title in all New France. He did excellent biological work on the beaver and the muskrat and, botanically, he became interested in the Pitcher Plant of which he sent specimens to Tournefort. Tournefort gave to the Pitcher Plant the generic name *Sarracenia* in honour of his correspondent.

Another French court-physician and naturalist, Hugues Gaulthier, lived at Quebec about 1750. He was the first to make a serious study of the production of Maple sugar. Between Newfoundland and Manitoba there grows a creeping shrub the bright red berries and foliage leaves of which contain a peculiar oil and have a spicy aromatic flavour. The plant is commonly called the *Aromatic Wintergreen* and scientifically *Gaultheria procumbens.* The generic name *Gaultheria* was given to the plant by Linnaeus in Gaulthier's honour.

Among other French Canadians who have contributed to our knowledge of Canadian plants are the Abbé Provencher who published his *Flore Canadienne* in two volumes in 1862, the Abbé Brunet, and the Abbé Moyen. At the present time Frère Marie-Victorin has in preparation a critical flora of Quebec, several chapters of which have already been published as papers.

John Macoun came to Ontario from Ireland in 1850. He was a naturalist and explorer. In pre-railway days he made an expedition from the east of Canada over the prairies, through the Peace River area, and over the mountains to the Pacific coast, and another expedition in the reverse direction; and he explored the prairies in 1879, 1880, and 1881. In the east he made botanical journeys in western Ontario, the Gaspé Peninsula, Nova Scotia, and Anticosti;

and from 1884 onwards he collected extensively in British Columbia, including Vancouver Island. By means of all these travels Macoun obtained a unique and very extensive knowledge of the plants of the Dominion, with the result that in the years 1884-1887 he was enabled to publish his *Catalogue of Canadian Plants*—the first general Canadian Flora.

John Macoun, in the course of his exploratory work, discovered many new species of animals and plants, most of which have been named by other scientists. At the end of his *Autobiography* is a list of 48 species discovered by Macoun and given the specific name *Macounii* by their describers. The list includes 20 Flowering Plants, 14 Mosses, 2 Lichens, 6 Hepaticae, 1 Starfish, 2 Mollusks, 1 Butterfly, and 2 Fish, and is a remarkable tribute to Macoun's activity as a collector. Macoun's memory is also perpetuated in Mt. Macoun, the name of a fine mountain which lies to the south of the Sir Donald Range in the Rockies.

In most of the Provinces of the Dominion the plants are being studied to a greater or less degree. Thus Frère Marie-Victorin is engaged in his critical study of the flora of Quebec, Professor Davidson at Vancouver is at work on the plants of British Columbia; and, as some sign of activity on the prairies, it may be mentioned that the Natural History Society of Manitoba in 1922 issued a check-list of the Manitoban Flowering Plants and Ferns. However, on the whole, systematic botany in Canada is not making the progress which is desirable.

There are still vast areas of our country in which no botanist has ever yet set foot. We do not know the names of all the Flowering Plants and Ferns in the Dominion and, so far as our non-vascular Cryptogams are concerned, there must be hundreds of species which still await discovery. Moreover, the limits of distribution of the majority of our plants are at present but vaguely known. The floras most in use by Canadian botanists for the identification of Canadian plants are, for the east, *Gray's New Manual of Botany* and Britton and Brown's *Illustrated Flora of the Northern United States, Canada, and the British Possessions* and, for the far west, Rydberg's *Flora of the Rocky Mountains and Adjacent Plains,* all of which are works of United States origin. Our debt to their authors is very great; but, surely, it is time for us to make preparations for the writing of a comprehensive flora of our own.

A botanical survey of Canada should be undertaken. A central committee should be organized for the Dominion as a whole, and

each Province should have its own band of workers who would map out the country and collect plants systematically year after year. In every Province in one or more of the Universities there should be established a herbarium with a duly appointed keeper, and in the herbarium should be kept up-to-date a list of all the plants in the province together with dried specimens of each species. Also, at Ottawa, to take the place of the crowded and badly housed herbarium at the Victoria Museum, there should be built (possibly at the Experimental Farm) a special building to be known as the National Herbarium, and to this building should be sent duplicate specimens of all species found in the Provinces. The staff now in charge of the herbarium at Ottawa is entirely inadequate for the work to be undertaken and it would have to be supplemented. Dr. Malte, who singlehanded is attempting the unequal task of taking care of all the plants of the Dominion, should be given assistants who every summer could act as leaders of field parties. Those who would undertake the responsibilities of herbarium work at Ottawa should undergo a thorough course of preparation in one or more of the great botanical centres, such as the Gray Herbarium at Harvard University and the Royal Herbarium at Kew Gardens, London. The training of the experts required should begin at once, as the success of the undertaking would depend on their efficiency.

The carrying out of a thorough botanical survey of Canada would not only show that we are worthy of our great inheritance of living plant species and add much to our knowledge of the plant geography of the world, but it would increase our prestige among the commonwealth of nations and it would doubtless be of considerable economic importance. National prestige based on fine achievement in the realm of science, literature, and the arts is not to be despised because it cannot be evaluated in terms of dollars and cents, for it is one of those imponderables which encourage all good citizens to be loyal to their country and to make every further effort for its advancement. Concerning the economic advantages of the proposed survey, it is only necessary to add that the lack of such a survey has already led to administrative difficulties in the allotment of timber-limits for pulp-mills and that, if the survey were undertaken, it would probably yield results which in the course of time would amply repay the cost of the effort.

XIII. Botanical Gardens

Canada is well provided with experimental farms, but is almost entirely lacking in botanical gardens. Dr. A. W. Hill, the Director

of the famous Royal Botanic Gardens at Kew, made a tour of the Dominion a year ago. He was pleased to find at Vancouver "a small and very interesting botanic garden in course of development", but felt bound to remark that the general absence of botanical gardens in Canada is "a matter of deep concern and regret to the botanists of the Empire no less than to those of the Dominion itself".

Botanical gardens are not only havens of rest for the mind and a delight to the eye, but are of high educational importance. They permit of a proper display of the great wealth of the vegetable resources of the countries in which they are established, and they can also be used as centres for research in the sphere of genetics and for the introduction and improvement of economic and ornamental plants. Every large Canadian city, such as Ottawa, Quebec, Montreal, Toronto, Winnipeg, and Vancouver, might well add to its amenities one of these valuable institutions.

XIV. Wheat in the West

Among the cultivated plants of the Dominion wheat stands first in importance. A grain of wheat in itself is a very tiny thing, but the prosperity of western Canada is bound up with its existence. For it is not too much to say that, without the grain of wheat in its collective sense, the great city of Winnipeg with its 200,000 inhabitants, its broad streets, its imposing public buildings, and its busy cosmopolitan life, would not have advanced at the present day beyond the status of a small trading station. And without the grain of wheat in its collective sense there would, at the present time, be no University of Manitoba and I should not be here to-night addressing the Royal Society.

Wheat was first introduced into western Canada by the Selkirk Settlers and was planted by them not far from this spot in 1812. In 1904, the wheat crop was 56,000,000 bushels; in 1906 it was 102,000,000 bushels; and last year (1927) it exceeded 400,000,000 bushels. Canada has now become the greatest wheat-exporting country in the world.

The chief kind of wheat grown in the west is known as Marquis, and the discovery and introduction of Marquis wheat forms a romantic chapter in agriculture. It would take too long to tell the whole story here. I can therefore only say that from one grain of Marquis planted by Dr. Charles E. Saunders in an experimental plot at Ottawa in the spring of 1903 there was produced in 1918—just

15 years afterwards—in Canada and the United States a crop of 300,000,000 bushels, i.e. enough wheat to more than fill every elevator in the land. The Royal Society is proud to think of Dr. Saunders as one of its Fellows, and Canadians generally may take pleasure in the thought that the Dominion Government has rewarded Dr. Saunders for his services as Dominion cerealist by giving him a special pension. Long may he live to enjoy it!

XV. The Rust Disease of Wheat

Unfortunately, the wheat of the west, like all good things, has its enemies; and one of the worst of them is a parasitic fungus known as *Puccinia graminis* which attacks the leaves and stems, uses up the sugar there, and thus diminishes the amount of starch that can be stored in the wheat grains. Often the grains of rusted plants are so thin and poor that the crop is hardly worth gathering in. The losses to the west through rust, on the average, amount to many millions of dollars every year: in 1916 the decrease in the crop through rust amounted to about 100,000,000 bushels.

Rust creates great uncertainty in wheat-growing and, in the west, a remedy for combating the disease is in urgent demand. To meet the situation, the Dominion Government has recently established at Winnipeg a Rust Research Laboratory in which a group of carefully trained scientific workers are busily engaged studying the rust problem and seeking for its solution. Already some promising results have been obtained: for instance, it has been discovered that rust in grain fields can be kept down by dusting with very finely divided sulphur powder and that in bad rust years such dusting pays. The practicability of introducing sulphur dusting on a large scale, however, is at present only in the experimental stage. In respect to the varieties of rust attacking wheat in Canada, the Rust Laboratory is now yielding reliable information. By means of aeroplanes we are finding out where the spores come from in the spring, and it now appears that they are blown here from the wheat fields of the United States. The problem of breeding a rust-resisting variety of wheat with the milling and baking qualities of Marquis, with a high yield, and suitable for export, is engaging the most earnest attention of the workers among whom are not only plant-pathologists but also expert plant-breeders. Considering that the Rust Research Laboratory has only been in existence for a little over two years, there can be no doubt that the workers there have made great progress with their problem. The

work at the Rust Research Laboratory, thanks to the assistance of the Research Council, is being supplemented by that of other investigators at each of the universities of the three Prairie Provinces.

Among the scientific discoveries which have come from the Rust Laboratory may be mentioned the observations on the occurrence of mutations in the Rust of wheat by Dr. Margaret Newton and Mr. Thorvaldor Johnson: these investigators, for the first time, have observed a new form of rust spring spontaneously from an old form. They seem to have had the process of evolution in the Rust Fungi going on under their very eyes.

XVI. J. H. Craigie's Investigations on Sex in the Rust Fungi

But the most striking discovery at the Rust Laboratory, made within the last year by Mr. J. H. Craigie, is concerned with the sexual processes of *Puccinia helianthi,* the Sunflower Rust Fungus, and *Puccinia graminis,* the Wheat Stem Rust Fungus.

During the last ten years, the investigations of Mathilde Bensaude in France (1918), of Hans Kniep in Germany (1919), of Mounce, Dorothy Newton, and Hanna in Canada, and of other botanists in Belgium, Austria, and elsewhere have shown conclusively that sexual processes take place in Mushrooms and Toadstools. In the simplest Toadstools the spores produced by a single fruit-body look all alike, but physiologically they fall into two groups which, for the sake of distinction, we may call (+) and (−). When two (+) spores are sown together or two (−) spores are sown together on nutrient agar in a Petri dish, no sexual reaction takes place between the paired mycelia (fungus plants in the vegetative stage) and the mycelia usually remain infertile; but, when a (+) and a (−) spore are sown side by side, then the (+) and (−) mycelia interact sexually and soon produce fruit-bodies which are perfectly fertile in that they develop and liberate millions of new spores.

Now the Rust Fungi are distant relatives of Mushrooms and Toadstools. Therefore, after the chief facts concerning sex in Mushrooms and Toadstools had been elucidated, it seemed highly desirable that some attempt should be made to solve the hitherto much discussed but baffling problem of sex in the Rust Fungi.

The Rust Fungi are obligate parasites, i.e., they refuse to develop on artificial media, such as nutrient agar, and will only grow on the living leaves and stems of their host-plants. On this account, investi-

gators had recoiled from the difficulty of sowing spores (sporidia) on living leaves singly and in pairs to see what reaction would take place. The result was that, at the time the Rust Laboratory was established two and a half years ago, no experiments had ever been made on sex in the Rust Fungi.

Immediately the Rust Laboratory was opened Mr. Craigie, with rare determination and all the optimism of youth, applied himself to solve the sex problem in the Rust Fungi and, as a result of two years of work, a greater success than was at first even hoped for has rewarded his efforts.

By sowing haploid spores (sporidia) of *Puccinia helianthi*—the Sunflower Rust—on Sunflower leaves singly and in pairs and using as a test of sexual reaction the production of diploid structures known as aecia (cluster-sups), Mr. Craigie proved conclusively that the Sunflower Rust Fungus exactly resembles the simpler Mushrooms and Toadstools in having spores (sporidia) of two sexes, (+) and (−). And similar experiments made on *Puccinia graminis*—the Stem Rust Fungus of Wheat—by sowing spores (sporidia) on the leaves of the Barberry (the alternate host-plant) yielded similar results. An account of all these mating experiments was given in a letter to *Nature* published on July 23, 1927.

With the help of the experience gained by making hundreds of experiments of the kind just indicated, Mr. Craigie proceeded to make a most beautiful and important botanical discovery—nothing less than the discovery of the function of the pycnia of the Rust Fungi.

In a Rust pustule obtained by sowing a single sporidium of the Sunflower Rust Fungus on a Sunflower leaf or by sowing a single sporidium of the Wheat Stem Rust Fungus on a Barberry leaf, Craigie found that, as a rule, only one kind of fungus organ appeared, namely, *pycnia* (on the upper side of the leaf), but that, when he sowed two sporidia of opposite sex on a leaf together, then the usual pycnia appeared on the upper side of the leaf and some days afterwards *aecia* on the lower side of the leaf. It has been known since de Bary made his classic investigations in 1864-65 that the aeciospores on a Barberry leaf are carried off by the wind and that, if they settle on the leaves or stems of wheat plants, they can germinate there, infect the tissues with the mycelium, and so produce the rust disease on the wheat plant; but de Bary could not explain the function of the pycnia, and the function of these organs has been a standing puzzle since his time. Thousands of botanists have looked at them and a number

of very able botanists have studied and discussed them, but no one before Craigie began his experimental work was able to penetrate their secret. The most prevalent view was that they were functionless male organs—in the evolutionary past once useful but now, after the disappearance of certain hypothetical female structures (trichogynes), of no use whatever.

Each pycnium is a flask-shaped structure which produces great numbers of very minute spores known as *pycnospores* (spermatia). When a pycnium matures, it excretes a drop of nectar at its mouth and the nectar is laden with thousands upon thousands of the tiny pycnospores. The excretion of the drop of sweet fluid—the nectar—had always struck me as a most remarkable fact and, since my student days, I had often pondered upon it.

One day in May, 1927, a little less than a year ago, I was in the Rust Laboratory, inspecting the experiments then in progress. Mr. Craigie had numerous rust pustules of monosporidial origin on his Sunflower and Barberry leaves. There were pycnia on the upper sides of the pustules and each pycnium had excreted a drop of nectar.

A solitary fly—one of the first of the season—had entered the greenhouse; and Mr. Craigie and I saw it settle on a Sunflower leaf, run up to a rust pustule, suck up the nectar from the pycnia, and then fly off to another leaf and repeat its operations. A decision was thereupon made to copy the actions of the fly, i.e. to take (+) pycnospores from (+) pustules to (−) pycnia in (−) pustules and, *vice versa,* (−) pycnospores from (−) pustules to (+) pycnia in (+) pustules; and it was predicted that, as a reaction, aecia and aeciospores would be produced on the under side of each pustule. I felt so confident that the fly had provided the clue which would lead to the solution of the pycnial problem that, in my excitement, I burst out into biblical language and said to Mr. Craigie: "Go to the Fly thou uredinologist; consider his ways, and be wise!"

Mr. Craigie carried out the proposed experiments last summer with the result that everything went off successfully. Mixing the pycnial nectar by hand did, as predicted, lead to the production of aecia, as shown by the accompanying illustrations (lantern slides). Mr. Craigie has therefore taught us that the function of a pycnium is to produce pycnospores which, when transferred to the mouth of a pycnium of opposite sex, affect the mycelium of opposite sex underlying the pycnium and cause it to change from the haploid to the diploid condition, thus leading to the formation of aecia and aeciospores.

Craigie's discovery, which was announced in a letter to *Nature* published November 26, 1927, is a great achievement and, in its own field, as a step in the progress of science, stands perhaps on a level with the discovery of the function of the islets of Langerhans in the pancreas—the insulin discovery—made by Banting, McLeod, Collip, and Best at the University of Toronto, and with the discovery of the calcium-regulating function of the parathyroid gland made by Collip at the University of Alberta. Craigie's work has already attracted the attention of the botanists of the whole world, for it is realized that his elucidation of the function of the pycnia is not only of first-rate interest in itself but is one of those fruitful discoveries which is sure to become the starting point for much further scientific progress.